Virtuous Circles and the Case for Aid

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ABSTRACT

It is sometimes argued that foreign aid leads to a virtuous circle in which growth becomes self-reinforcing. We study two versions of this argument, using a modified neoclassical growth model in which the effects of parameter changes and capital accumulation are amplified. Simulations are used to quantify the welfare benefits from aid transfers. We find that, contrary to expectations, amplification makes only a modest difference to the welfare benefits from aid. This is true even when aid allows a faster exit from a vicious circle or poverty trap.

Keywords: Foreign aid, amplification effects, virtuous circles, vicious circles
JEL classifications: F35, O40

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Everything is obvious — once you know the answer
— Title of book by Duncan Watts

1 Introduction

The Harvard commencement address of 5 June 1947 was given by the Secretary of State, George Marshall. His speech was less than thirteen minutes long, but was hailed by one foreign minister as 'one of the greatest speeches in world history'.[1] In the speech, Marshall set out a clear vision for the problems facing postwar Europe, and how aid could be used to address them. He was optimistic about what large-scale aid could achieve: 'The remedy lies in breaking the vicious circle and restoring the confidence of the European people in the economic future of their own countries'.

The Marshall Plan is often seen as the first major aid programme, and perhaps the most successful. The objective sketched by Marshall, that aid could break a vicious circle, echoed the ideas of Rosenstein-Rodan (1943) a few years earlier. And as development economics began to take shape in the 1950s, vicious circles and coordination failures were widely discussed. They were central to the visions of Singer (1949) and Nurkse (1953), and discussed extensively in Hirschman (1958). Lewis (1955, chapter V) stressed the interdependence of capital investments. These early writers tended to see underdevelopment as representing one or more coordination failures, and emphasized that some conditions of poor countries would be self-perpetuating.

A related view suggested that, if only growth could be initiated, it would quickly become self-reinforcing. The metaphor of a 'take-off' into sustained growth became popular, with its implication that getting off the ground is harder than staying in the air. There are many possible mechanisms through which growth could promote further growth. In the recent literature, it has become common to emphasize political economy forces, as in Krueger (1993), Besley and Persson (2011) and Acemoglu and Robinson (2012), in which good political outcomes promote good economic outcomes, and vice versa.

It is clear that these ideas have a long history, and that virtuous and vicious circles are widely regarded as important. Yet this also suggests a puzzle. Although global spending on foreign aid is more important than ever before, and currently exceeds $150 billion each year, economists studying foreign aid have rarely investigated the quantitative implications of virtuous circles, or exit from vicious circles. The true importance of virtuous circles remains unknown, and it is not easy to establish

[1] The minister was the British Foreign Secretary, Ernest Bevin, quoted in Judt (2005), p. 91.

their existence in the cross-country data. The regressions common in the literature are not always well-suited to capturing such ideas, or the broader notion that aid can be a catalyst for successful development.

In this paper, we take a different approach. We consider two extensions to the neoclassical growth model, and study their quantitative implications using simulations. In the first extension, capital accumulation is amplified by an externality. Perhaps unexpectedly, for reasons we explain below, this mechanism does not strengthen a welfare-based case for aid. In the second extension, we study an economy temporarily trapped in a vicious circle of low income, low saving and low investment. In this case, an economy needs to achieve 'escape velocity' or take-off, generating a virtuous circle in which development leads to higher investment. Our results indicate that, if aid allows a faster exit from a medium-run poverty trap, the benefits of aid are significant, but still modest relative to international differences in consumption per capita. This is true even if the growth process can take advantage of an externality to capital.

These results are developed using simple modifications to the Ramsey model. Although the model is stylized, it helps to isolate some of the dilemmas that aid donors have to resolve. In models of this type, donors could decide to prioritize (1) the countries with the best growth prospects; (2) those where aid can do the most to improve growth prospects; (3) those most in need of higher consumption; or (4) those where aid can do the most to improve consumption prospects. It is often argued that aid should be given to countries with good institutions, but these countries may be destined for fast growth in any case; hence countries in category (1) are less in need of aid, and should be a lower priority, other things equal. The orthodox justifications for aid tend to emphasize category (2): aid should be directed to where it can do the most to improve growth prospects. The neoclassical growth model, with an explicit objective function based on the time profile of consumption, naturally suggests that considerations (3) and (4) will also be important. We show that this perspective can overturn or qualify some standard intuitions about the relevance of virtuous circles and medium-run poverty traps for donor decisions.

To avoid misunderstandings, we emphasize that the paper is not about the overall role of virtuous circles in the growth process. Taking a long view, the sustained divergence in national economic fortunes that began in the nineteenth century suggests that virtuous circles could matter. Our paper is focused on a narrower question, which is whether the idea can be used to strengthen the case for aid. It might seem that donors can take advantage of virtuous circles; but so can other sources of investment, such as domestic saving, in which case the development path of an aid

recipient will not greatly differ from the path without aid.

In the models we consider, aid does generate significant welfare gains. But the gains look modest when set against the potential benefits of higher total factor productivity (TFP) in poorer countries, given the findings of the development accounting literature, reviewed in Caselli (2005) and Hsieh and Klenow (2010). Even in models with virtuous or vicious circles, the welfare benefits from a realistic level of aid are an order of magnitude smaller than the benefits from eliminating TFP differences. These results suggest that it would be interesting to study models and policies in which aid has a direct effect on productivity, including models in which the effects of productivity changes are amplified by virtuous circles. It would also be interesting to quantify the effects of aid in models based on coordination failures. However, we treat those endeavors as beyond the scope of the paper.

The rest of the paper expands on these arguments as follows. In the next section, we briefly define amplification effects and vicious circles, and discuss the previous literature. Section 3 describes a modified version of the neoclassical growth model. Section 4 presents the simulation assumptions and some results. Section 5 introduces subsistence consumption, so that aid can be used to escape a medium-run poverty trap. Finally, section 6 concludes.

2 Discussion

The role of vicious and virtuous circles is a theme as old as development economics itself. Work in the 1950s often discussed the 'vicious circle of poverty', and the concept features heavily in a World Bank retrospective on development economics, Meier and Seers (1984). The early work emphasized the need for coordinated investment, and the role of low income as a constraint on investment. The textbook by Basu (1997, chapter 2) reviews some relevant contributions, but the range of potential mechanisms extends beyond those that have been formalized. Rostow (1956) was one of the first to discuss self-reinforcing growth and the wide range of candidate mechanisms.

Recent discussions of virtuous circles have emphasized mechanisms related to political economy and governance, treating these as endogenous. For example, Krueger (1993) discusses how trade policies and politics could interact to generate either vicious or virtuous circles. Bräutigam and Knack (2004, p. 259) argue that 'once governance begins to decline, a vicious cycle of inadequate revenues, low morale, and poor performance is all too easily created'.[2] Besley and Persson (2011)

[2]Sachs (2006) sketches a virtuous circle in which rising tax revenues strengthen political au-

highlight the possibility that investment in state capacity and political stability could be mutually reinforcing. In an extended discussion, Acemoglu and Robinson (2012, chapter 11) set out several mechanisms, including the interaction of the rule of law and political pluralism; positive feedback between inclusive political institutions and inclusive economic institutions; and the role of a free press in maintaining inclusive institutions.

Despite the appeal of these ideas, there have been few examples of 'quantitative theory'. Yet quantification seems needed, and can work against standard intuitions. To demonstrate this, we build on a tradition that analyzes aid in neoclassical growth models. Obstfeld (1999) used simulations of a model with endogenous saving to conclude that the effects of aid on consumption and output are relatively modest. Rajan and Subramanian (2008), using a growth model with exogenous saving, also found the effects to be modest.[3]

We combine amplification effects and virtuous circles with another long-standing argument: aid may be most effective where it is least needed. Informal versions of this idea go back to Friedman (1958) and Bauer (1969, 1971), who both questioned whether aid would usefully increase investment. They argued that, if the conditions for successful capital accumulation were in place, it would already have been accumulated. Versions of this idea are discussed by Eaton (1989), Temple (2010), Deaton (2013), and Carter (2014), among others. Carter (2014) studies its relevance in the neoclassical growth model. Although it seems natural to target aid at the countries where aid will have the largest effect on investment and growth, these may be precisely the countries which are destined to prosper even in the absence of aid. If the donor's decision problem is analyzed in welfare terms, a different set of countries may be identified as priorities — not those where aid does the most to raise growth, but where aid has the largest benefits for the lifetime utility derived from the entire consumption path, relative to a zero-aid benchmark.

Our emphasis on this point has a close precedent in the study of capital mobility by Gourinchas and Jeanne (2006). Using simulations of neoclassical growth models, they showed that, although foreign capital inflows bring capital accumulation and growth forward in time, the associated welfare benefits are surprisingly modest. This is because the economy would converge to its steady-state growth path even in the absence of capital inflows. One contribution of our paper is to show that

thority and public investment, which support further increases in revenues.

[3]They argued that this may explain why aid has muted growth effects in cross-country regressions. In related work with endogenous saving, some authors have allowed aid to finance public investment, as in Chatterjee, Sakoulis and Turnovsky (2003) and other work summarized in Turnovsky (2009).

similar ideas can be applied to foreign aid, even when aid is amplified by a capital externality or helps a recipient country to escape from a medium-run poverty trap.[4]

We now discuss amplification effects and virtuous circles in more detail. An example of amplification is that, for a given capital-output ratio, the long-run elasticity of output with respect to TFP is greater than unity in the Solow and Ramsey models.[5] Since the equilibrium capital-output ratio is pinned down by structural parameters, improvements in TFP lead to higher capital per worker, and this amplifies their effect. The extent to which the TFP change is amplified is increasing in the output-capital elasticity.

In this example, amplification arises due to endogenous changes in capital intensity, and the long-run elasticity of output to TFP is larger than the short-run elasticity implied by the production technology. This suggests a more general definition of amplification effects. The responsiveness of long-run equilibrium outcomes to a given change — perhaps a change in TFP, or in policy variables — can sometimes be attributed to one or more distinct mechanisms, involving one or more intervening variables. When a specific mechanism leads to larger equilibrium responses in one or more outcomes, we call this an amplification effect.[6] Often, the strength of the mechanism could vary, indexed by one or more parameters, and for some parameter values it could be absent altogether. To give a concrete example, our first quantitative exercise will consider a Ramsey model with a capital externality.

Within this class of effects, virtuous circles form a special case. Virtuous circles are usually thought of as unfolding over time, as part of a dynamic process in which the movements of two or more variables reinforce each other. In the growth case, we can think of the level of GDP per capita interacting with an additional state variable, such as institutional quality, human capital, or financial development. Growth leads to a change in this additional variable which promotes further growth. In our terminology, virtuous circles will typically lead to amplification, but not all amplification relies on virtuous circles. For example, externalities can generate amplification without requiring that two or more variables reinforce each other.

A genuine virtuous circle arises in Mankiw, Romer and Weil (1992). The introduction of human capital leads the elasticity of steady-state output with respect to the investment rate to be higher than in the standard Solow model.[7] In a related pa-

[4]The implications of the Gourinchas and Jeanne (2006) analysis for the study of foreign aid were previously discussed in Temple (2010) and Carter, Postel-Vinay and Temple (2015).

[5]A version of this point has been emphasized by Klenow and Rodriguez-Clare (1997) and Parente and Prescott (2000), among others.

[6]Note that our use of the term differs from that in Dutta, Leeson and Williamson (2013), who consider the possibility that aid leads to a polarization in political institutions.

[7]Acemoglu (2009, p. 370) briefly discusses the use of the Mankiw et al. production function

per that deserves to be better known, DeLong (1997) considers several mechanisms, such as a relative price of equipment that is endogenous to the level of development. Perry and others (2006) argue that poverty alleviation and growth are mutually supportive: reductions in poverty make it easier for the poor to invest, spurring further growth and poverty alleviation. Using firm-level data from Vietnam, Bai and others (2014) find that fast-growing firms see reductions in the share of their revenues extracted as bribes, suggesting that growth can alleviate corruption.[8] More generally, the list of candidate mechanisms for self-reinforcing growth may not be much shorter than the list of candidate growth determinants.

In contrast to our approach, some discussions of virtuous circles see them as tightly connected to multiple equilibria. Fast growth can arise in moving from one equilibrium to another, and this may involve dynamic adjustments which reinforce one another. From a policy perspective, however, a theory of equilibrium selection is needed, which seems more fundamental than whether or not a virtuous circle influences adjustment.[9] Growth can be self-reinforcing even when the equilibrium is unique, and amplification effects and virtuous circles seem worthy of study in their own right, independently of poverty traps or multiple equilibria.

Nevertheless, we will draw on the poverty trap perspective. When underdevelopment is conceived as a self-reinforcing vicious circle, the prospects for escape may depend on whether a virtuous circle is possible. This perspective helps to explain the longevity of Rostow's (1960) metaphor of take-off into 'self-sustained' growth. In our later analysis, we consider a medium-run poverty trap generated by a subsistence consumption constraint. Aid, by making available extra resources that can be used for investment, allows a faster escape from the poverty trap, especially when amplified by a capital externality.

3 The model

To study an amplification effect, we adapt an otherwise standard Ramsey model to include 'institutional quality', which is treated as endogenous to GDP per capita.

in a Ramsey model with investment taxes; the aggregate consequences of tax distortions are then amplified. Endogenous investments in human capital are also present in the models of Erosa, Koreshkova and Restuccia (2010) and Manuelli and Seshadri (2014).

[8] Voors, Bulte and Damania (2011) find that positive income shocks in corrupt countries can raise corruption, but a virtuous circle can arise when corruption is low.

[9] Acemoglu (2009, p. 116) draws a distinction between models with multiple equilibria, and models with multiple steady-states. In the former case, the equilibrium can change when agents simultaneously change behaviour or expectations, giving rise to indeterminacy; in the latter case, the equilibrium path and the final outcome are determined by initial conditions. See Mourmouras and Rangazas (2007) for analysis of aid in a model of the latter type.

In the model, households do not internalize the effects of their investment decisions on institutional quality, and hence invest too little from society's point of view. But for the aims of this paper, we are not primarily interested in the externality, or in deviations from a social planning solution. Instead, we examine how the externality influences the welfare benefits of aid.

The key point driving our results is that there are two opposing effects. The first effect is the obvious one: the externality enhances the productivity gains associated with investment, which makes aid-funded investment more valuable, and increases the prospects for aid-funded growth. The second effect is less well understood. Relative to an economy without an externality, an economy with an amplification effect is destined to grow rapidly in any case. This implies strong consumption prospects even in the absence of aid. In quantitative terms, this second effect can easily dominate the first. When this happens, the welfare gains associated with aid are more important in a world *without* amplification, contrary to standard intuitions. We show this using a model that is stylized, but we do not need a more complicated model to make our main points. As Paul Klee said of visual art, the aim is not to reproduce reality, but to make something visible.

We consider a world with a single homogeneous good, and focus on a small aid recipient that receives exogenous transfers, shared equally among identical private households. There are no other international capital flows. We treat the labor force as equal to the population. Relative to the standard Ramsey model, we introduce a productive role for institutional quality Q at the aggregate level. We also assume that institutional quality is itself a function of output per capita: more precisely, Q has an elasticity with respect to output per capita of θ where $\theta < 1$. This structure generates an externality to the aggregate capital stock.[10]

For simplicity, we initially assume population is constant and there is no technical progress. The aid recipient receives a constant flow of aid per capita at each instant, denoted $a(t)$. In obvious notation, private households are each solving the following

[10]In the terminology of section 2, this is an amplification effect rather than a virtuous circle, because it will reduce to a model with a capital externality. Put differently, although there is an extra state variable in the model at first glance, it can be eliminated from the system of equations, and the resulting system will then be identical to the case of a capital externality.

optimal control problem:

$$\begin{aligned} & \max_{\{c(t)\}} \int_0^\infty u(c(t))e^{-\rho t}dt \\ \text{subject to:} \quad & \dot{k(t)} = A(t)Q(t)f\left(k(t)\right) + a(t) - c(t) - \delta k(t) \\ & Q(t) = \left(Y(t)/L(t)\right)^\theta \\ & k(0) \text{ given.} \end{aligned}$$

where $k \equiv K/L$ and a standard transversality condition applies. In what follows, we suppress the time index except where its inclusion is useful for clarity. Factor markets are perfectly competitive, and again for simplicity, we can think of the decision-makers as private households which carry out production and investment. The households are too small to internalize the effects of their choices on Q, and hence their intertemporal choices will satisfy the standard Euler equation:

$$\frac{\dot{c}}{c} = \frac{1}{-\varepsilon_{u'(c)}}\left(A \cdot Q \cdot f_k(k) - (\rho + \delta)\right)$$

where $\varepsilon_{u'(c)}$ is the elasticity of marginal utility with respect to consumption, equal to $-\sigma$ in the case of isoelastic utility, where $1/\sigma$ is the elasticity of intertemporal substitution.

We assume a Cobb-Douglas production function, so that $AQf(k) = AQk^\beta$. Compared to the standard Ramsey model, the steady-state solution and transitional dynamics are modified because Q is endogenous to aggregate output per capita, $y \equiv Y/L$. The assumptions imply:

$$y = Ak^\beta y^\theta$$

and hence a reduced-form aggregate relationship:

$$y = A^{\frac{1}{1-\theta}} k^{\frac{\beta}{1-\theta}}$$

Note that the reduced-form output-capital elasticity (the one that might be estimated by an empirical researcher using aggregate data) is $\beta/(1-\theta)$, and this will play a role in what follows. Also note that, to obtain a conventional steady-state, we need to assume that $\beta < 1 - \theta$, so that social returns to capital are diminishing.

Using the relationship $Q = y^\theta$, the private return to capital, used by households in their intertemporal decisions, is given by:

$$\beta A^{\frac{1}{1-\theta}} k^{\frac{\beta}{1-\theta}-1}$$

The steady-state level of k is defined by:

$$k^* = A^{\frac{1}{1-\beta-\theta}} \left(\frac{\beta}{\rho + \delta} \right)^{\frac{1-\theta}{1-\beta-\theta}}$$

and hence steady-state output per capita is given by:

$$y^* = A^{\frac{1}{1-\beta-\theta}} \left(\frac{\beta}{\rho + \delta} \right)^{\frac{\beta}{1-\beta-\theta}}$$

The absolute magnitudes of the elasticities of steady-state output per capita with respect to TFP and other structural parameters are increasing in θ. We will use this model to study the relationship between the welfare benefits of aid and amplification effects. Note that the model reduces to the standard Ramsey model if $\theta = 0$. Also note that the long-run level of output per capita is independent of the level of aid, as in Brakman and van Marrewijk (1998) and Obstfeld (1999).[11] This does not mean aid is ineffective, however. Since aid increases the resources available for consumption and investment, it increases welfare in two ways: it allows faster convergence to the steady-state, and higher consumption.

4 Simulations

In this section, we first describe the assumptions we use to simulate alternative economies. We then study aid in a basic Ramsey model; this analysis is a simple variant on Obstfeld (1999), but with explicit calculations of welfare effects. Then, we consider how these welfare effects are modified by introducing a capital externality. We show that this form of amplification does not increase the welfare benefits associated with aid (relative to a zero-aid counterfactual), and explain the reasons for this result. In the next section, we will examine whether the result can be overturned by a model with a medium-run poverty trap.

Our calibration draws on Carter, Postel-Vinay and Temple (2015), including the choices of the structural parameters. We adopt isoelastic utility with $\sigma = 2$ and set $\rho = 0.03$, $\delta = 0.06$. Note that $\sigma = 2$ corresponds to the mean of the many estimates compiled by Havranek and others (2015). Again following Carter, Postel-Vinay and Temple, we construct our aid recipient as an amalgam of low and middle-income aid recipients, based on World Bank country classifications and taking averages of

[11] This result does not apply in overlapping generations models; see Eaton (1989) and Dalgaard, Hansen and Tarp (2004). However, OLG models are less well suited for our purposes, because of the complexity associated with analysing welfare effects in OLG settings.

the relevant data from version 6.3 of the Penn World Table (including China and India). On this basis, the capital-output ratio for our aid recipient is 2.00 and output per capita is \$5790; the model can then be used to infer the value of A. Across experiments, we assume the donor always has the same relative quantity of aid to disburse — a sum equivalent to 20% of recipient GDP at time zero. A constant, exogenous aid transfer of this magnitude is then made in perpetuity.

One point to bear in mind is that, as we vary the assumptions about parameters, the steady-state level of output will vary. An alternative approach would be to keep the same steady-state position, and vary the initial conditions. We think our approach is preferable, because it relates more closely to the decision problem facing a donor: the donor observes output per capita levels and capital-output ratios in the data, but will make different calculations about the steady-state growth path, depending on assumptions about the production technology. Therefore, we calibrate parameters so that alternative cases match the observed data, and allow the height of the balanced growth path to vary with β, the output-capital elasticity, and θ, the strength of the externality.

We emphasize the distance from steady-state because it will play a role in interpreting our results. The welfare effects of aid, relative to a zero-aid counterfactual, depend partly on whether the recipient country would prosper even without aid (Carter 2014). In the current setting, a country which is a long way below its growth path is destined to grow especially quickly. For such a country, aid may have a substantial effect on growth, but the economy would grow quickly in any case. This mechanism tends to limit the welfare benefits of aid, where the underlying logic is similar to that in Gourinchas and Jeanne (2006).

To carry out the simulations, we use the relaxation algorithm of Trimborn, Koch and Steger (2008), ultimately based on a finite-difference method. Their implementation of the algorithm allows the fast and convenient numerical solution of a system of differential equations, when a solution exists. It can easily handle infinite-horizon problems, of the type we analyze here. We could have chosen to solve a discrete-time version of the model using recursive methods, as in the aid study by Carter (2015), but for our purposes, the relaxation algorithm is faster, and easier to implement.

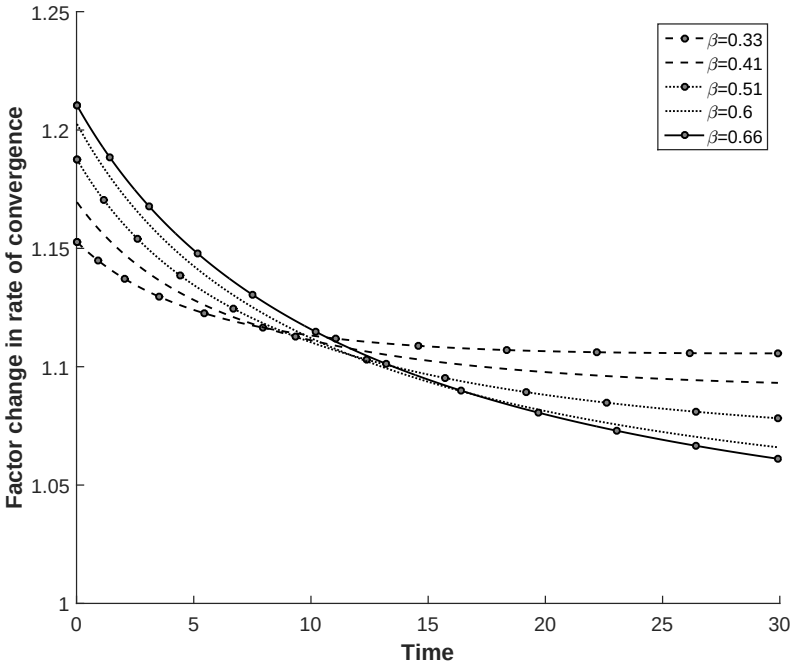
4.1 The Ramsey model with aid

We start by analyzing aid in the standard Ramsey model, which corresponds to $\theta = 0$. This simple case will help in understanding our later results: we show that a higher output-capital elasticity β increases the scope for aid-funded growth, but does not strengthen the case for aid. We explain the associated reasoning, which

will extend to our later cases with amplification effects and vicious circles.

Note that a larger β entails a larger marginal product of capital for any given level of the capital-output ratio. Hence, the larger is β, the greater the impact of aid-induced investment on the growth rate. In our simulations, when β is larger, the optimizing household chooses a higher rate of investment as a proportion of output. Moreover, aid increases the rate of convergence to the steady-state: this is shown in Figure 1, which plots the factor increase in the convergence rate made possible by aid.[12] Early in the transition, the effect of aid on the convergence rate is especially marked for high values of β. Thus far, the results are in line with intuition.

Figure 1: Aid and convergence rates for different values of β



This figure shows the effect of aid on the rate of convergence, defined here as $(dy/dt)/(y - y^*)$, for five levels of β, the output-capital elasticity. The effect is defined as the factor increase in the convergence rate made possible by aid. The level of aid is constant, equal to 20% of the recipient's initial output, given in perpetuity.

But a more important benchmark is the impact of aid on the welfare of households. We study this using Hicksian equivalent variation (HEV) as in Gourinchas and Jeanne (2006) and Carter, Postel-Vinay and Temple (2015). This allows us to compare lifetime utility with aid to the lifetime utility that would obtain under a zero-aid baseline scenario. The HEV is the constant proportional change in con-

[12] Away from steady-state, alternative definitions of convergence rates will typically give different results. We use the first measure of the four considered by Mathunjwa and Temple (2007).

sumption at each instant, relative to the baseline, that would generate the same change in lifetime utility as the scenario of interest. Under isoelastic utility, this is given by:

$$\lambda = \left(\frac{U_{aid>0}}{U_{aid=0}}\right)^{\frac{1}{1-\sigma}} - 1$$

if $\sigma \neq 1$, and $\lambda = exp(\rho \cdot (U_{aid>0} - U_{aid=0})) - 1$ if $\sigma = 1$.

For example, in our baseline simulation where $\beta = 1/3$ and $\theta = 0$, aid equal to 20% of initial GDP generates the same welfare benefits as raising the original consumption profile by 21.6%. That is clearly a significant gain. For comparison, it is the same welfare gain that would be achieved by a sustained step change in total factor productivity of 16%. At the same time, it is clear from either benchmark — the HEV gain, and the equivalent TFP change — that aid at this level would fail to eliminate the welfare differences between rich and poor countries, given the scale of the international differences in TFP and consumption per capita.[13]

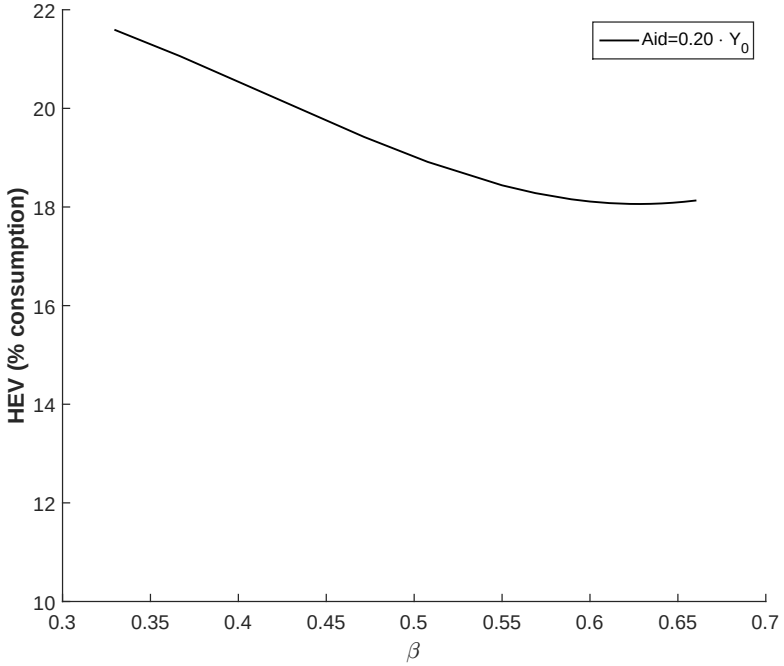
This raises the question of how the welfare gains vary with parameter assumptions. Figure 2 shows that aid has *lower* welfare benefits, in HEV terms, for higher values of β. To understand this, consider the prospects for consumption in the absence of aid. If these prospects are good, then aid will make less difference to welfare than if the prospects for consumption are less strong. Put differently, when β is high, aid recipients are less in need of assistance from a lifetime-utility perspective, and the welfare benefits of aid are diminished accordingly. This shows how consideration of welfare effects can overturn intuitions that rely solely on growth outcomes, even in a simple model.

4.2 Amplification effects

We now consider a capital externality, and hence some degree of amplification. This corresponds to selecting a θ (where $0 < \theta < 1 - \beta$), and introduces some extra complexity. Again, we study growth first. Figure 3 illustrates the effect of aid on initial growth rates. On the horizontal axis, we vary the reduced-form output-capital elasticity $\beta/(1-\theta)$. The dashed line shows growth as a function of β when there is no externality, so $\theta = 0$. The solid line is based on setting $\beta = 1/3$ and plots growth as a function of the corresponding value of $\beta/(1-\theta)$, where θ is implicitly increasing along the x-axis.

[13] One reason for this result is that aid does not greatly alter the path of the capital stock: in this baseline simulation, the capital stock with aid is never more than 4% higher, at any given instant, than in the case without aid.

Figure 2: The welfare effect of aid as β varies

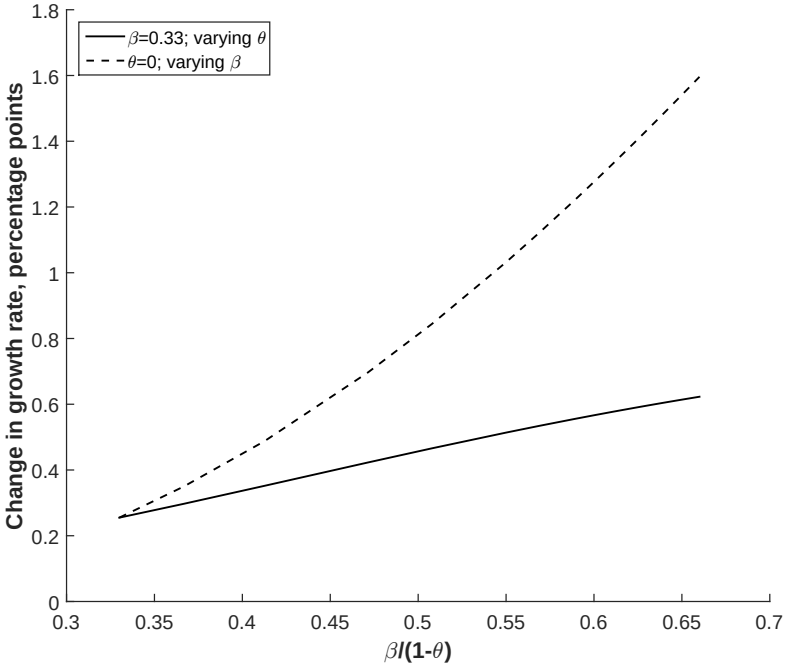


This figure shows the welfare benefit from aid, measured by Hicksian equivalent variation, as the output-capital elasticity varies. The level of aid is constant, equal to 20% of the recipient's initial output, given in perpetuity.

We can see how growth responds as the output externality becomes more important. We find that — as expected — aid has a greater impact on growth for higher values of θ, but the effect is modest. There are several mechanisms that limit the size of the effect as the externality becomes more important. First, the effect working via institutional quality is not internalized by households, which means it has no direct impact on investment decisions and a limited impact on growth rates. Second, when we calibrate the model to the observed data, the *private* marginal product of capital is lower for higher values of θ. In turn, the investment rate is lower for all levels of k.

For welfare effects, the corresponding results are shown in Figure 4, again using the Hicksian equivalent variation. As before, θ is implicitly increasing along the x-axis of the figure. It is clear from the downward slope of the solid line that the welfare gains from aid, in HEV terms, are decreasing in the extent of the externality. In other words, an observer of a given economy could not conclude that the welfare benefits of aid will be greater with amplification; the reverse is the case. The intuition is that an economy with a larger amplification effect — with higher θ — has relatively good consumption prospects in any case. Hence the welfare benefits from aid, relative to

Figure 3: The growth effect of aid, with and without amplification



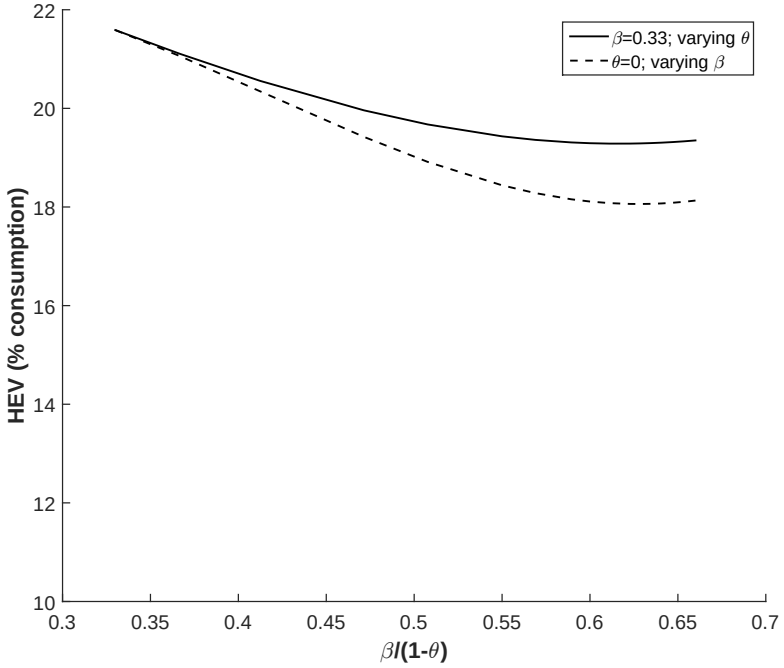
This figure shows the effect of aid on the annualized rate of output growth, measured over the first four years of the simulation, as the reduced-form output-capital elasticity $\beta/(1-\theta)$ varies. The effect on growth is defined as the growth rate with aid, minus the growth rate in the zero-aid counterfactual. The dashed line sets $\theta = 0$, the solid line sets $\beta = 1/3$. The level of aid is constant, equal to 20% of the recipient's initial output, given in perpetuity.

a zero-aid benchmark, are less.

A more subtle finding is also evident from Figure 4. The welfare effect of aid is somewhat greater, for any given value of $\beta/(1-\theta)$, when there is an externality ($\theta > 0$) compared to when the variation in the reduced-form output-capital elasticity arises solely from variation in β. In this limited sense, a virtuous circle strengthens the case for aid. A researcher who knew the reduced-form output-capital elasticity would infer larger welfare gains when assuming that there is an amplification effect. When a given reduced-form output-capital elasticity arises partly through an externality, aid recipients are relatively worse-off in the long run, and hence benefit more from aid than in the standard (no externality) case.

The relation between the findings and those of Gourinchas and Jeanne (2006) is worth discussing in more detail. They used the Ramsey model to study the welfare benefits of foreign capital inflows, and showed that the benefits were modest, because a recipient economy would converge to its steady-state relatively quickly even in the absence of such flows. Put differently, accelerating convergence to the steady-state

Figure 4: The welfare effect of aid, with and without amplification



This figure shows the welfare effect of aid in terms of Hicksian Equivalent Variation, as the reduced-form output-capital elasticity $\beta/(1-\theta)$ varies. The dashed line sets $\theta = 0$, the solid line sets $\beta = 1/3$. The level of aid is constant, equal to 20 per cent of the recipient's initial output, given in perpetuity.

(as made possible by capital flows) is less valuable than might have been expected. The same logic extends to aid: we study grants, which are more valuable to the recipient than loans, but the associated welfare gains remain modest, at least when set against international differences in consumption per capita. To overcome this logic, either the recipient economy would need to start a long way below steady-state, or the rate of convergence — in the absence of transfers — would need to be much slower.[14] In the next section, we will study a model in which convergence is slow.

In passing, we note that virtuous circles may have wider interest. They help to rationalize a number of empirical findings: the tendency for countries to converge to their steady-states at a slow rate, and the sharp contrast between observed transitional dynamics and those of the standard Ramsey model, since the latter typically generates initial real interest rates and growth rates that are implausibly high. Further, when estimated directly from cross-country data, the output-capital elasticity

[14] Alternatively, as discussed in Obstfeld and Taylor (2004, pp. 262-265), a higher discount rate could imply larger welfare gains.

is often found to be higher than the capital share.[15] This could be attributed to endogeneity problems or, as in Mankiw, Romer and Weil (1992), to the complementary role of human capital; but amplification effects and virtuous circles provide an alternative explanation, in which aggregate relationships between output and inputs differ from firm-level production functions. Beaudry, Collard and Green (2005) found that capital accumulation heavily influenced changes in the distribution of output per worker over 1960-1998, and that the social returns to capital appear to have increased over time. These patterns could readily arise in a world with virtuous circles, working through externalities or other means. Such mechanisms can also rationalize aggregate output-capital elasticities that vary across countries, even with a common Cobb-Douglas production technology at the firm level. These possibilities suggest that virtuous circles warrant more research.

5 Vicious and virtuous circles

The analysis thus far might seem counter-intuitive: surely virtuous circles must strengthen the case for aid? To derive that result, one approach might be to revisit Rostow's emphasis on the need for take-off into self-sustained growth (Rostow 1956, 1960). One interpretation is that growth is self-reinforcing, but first an economy must achieve escape velocity, in order to break out of a vicious circle. Rosenstein-Rodan (1961) quotes a 1957 MIT report: 'Launching a country into self-sustaining growth is a little like getting an airplane off the ground. There is a critical ground speed which must be passed before the craft can become airborne'.

With this in mind, we modify the Ramsey model so that aid recipients have Stone-Geary preferences, and may begin a growth process with living standards close to subsistence. Christiano (1989) refers to this version of the Ramsey model as the *slow convergence model*. Although simple, it helps to capture the idea of a vicious circle: households are too poor to fund investment after meeting consumption needs, and remain poor because they do not invest. If the economy can be trapped for some time in a position of low income and low investment, and convergence is slow, then aid could be especially valuable.

In principle, technical progress will eventually resolve the problem, but the transition dynamics may be protracted. In this version of the model, the balance of op-

[15] Examples of high estimates of output-capital elasticities for developing countries include Benhabib and Spiegel (1994) and Kim and Lau (1994). Barro and Sala-i-Martin (2004, pp. 112-118) explain how the Ramsey model with a low output-capital elasticity generates quantitative predictions that are at odds with the data; see also King and Rebelo (1993). For a critique of the empirical relevance of capital externalities, see Benhabib and Jovanovic (1991).

posing forces changes. Now, it is especially useful for investment to have a larger effect on output. This is because a medium-run poverty trap implies good consumption prospects only in the distant future, when capital accumulation and technical progress have overcome the subsistence constraint. The virtuous circle of rising income and rising investment allows aid to accelerate recipients away from subsistence consumption more rapidly, without implying a bright near-term future even in the absence of aid. As a result, aid may be most effective for those recipients where an amplification effect is present.

The use of Stone-Geary preferences is attractive for another reason: they help to bring the predictions of the Ramsey model closer to the data.[16] Under these preferences, the elasticity of intertemporal substitution (EIS) is increasing in the level of consumption, which is consistent with much of the microeconometric literature on consumption in developed countries: see, in particular, Attanasio and Browning (1995), Blundell, Browning and Meghir (1994) and Crossley and Low (2011). Consistent with this, Havranek and others (2015) find that, across countries, estimates of the EIS are positively correlated with GDP per capita. The theoretical importance of a variable EIS has been emphasized by Bliss (2007, 2008).

With Stone-Geary preferences, utility at each instant is given by:

$$U(c) = (c - \bar{c})^{1-\sigma} / (1 - \sigma)$$

where the new element $\bar{c}$ can be interpreted as a subsistence consumption constraint or, more generally, as a way of ensuring that poor households have a lower EIS. An economy close to the consumption level $\bar{c}$ fails to grow, even when the marginal product of capital is high, because households are too poor to want to sacrifice consumption. In the pithy formulation of Nurkse (1953), a poor country is poor because it is poor.

We include a role for technical progress, which renders the subsistence constraint irrelevant in the long run. If the initial capital stock is sufficiently high, and the parameter assumptions permit capital intensity to increase despite the subsistence constraint, the economy will converge to an asymptotic balanced growth path. The capital-output ratio converges asymptotically to a level which is independent of $\bar{c}$, and consumption will always be higher than the subsistence level. Hence, our use of the terms 'poverty trap' and 'escape velocity' has been a little loose: the economy is not trapped indefinitely. Nevertheless, it may take a long time for the economy

[16] References include Christiano (1989), Rebelo (1992), King and Rebelo (1993), Ben-David (1998), Kraay and Raddatz (2007), Ohanian, Raffo and Rogerson (2008) and Steger (2009). For a different model with slow convergence, see Rappaport (2006).

to achieve significant growth, and in this weaker sense the terms are valid.[17]

As well as technical progress, we allow a role for population growth, and treat household utility as weighted by household size at each instant. We can accommodate technical progress and population growth by defining the endogenous variables in terms of efficiency units; but endogenous institutional quality complicates this. We assume that institutional quality is a function of output per capita, rather than output per efficiency unit of labor. This seems the most natural approach, but the long-run growth rate will now exceed the rate of exogenous technical progress. This is because our assumptions imply that institutional quality is growing continually along the balanced growth path.

As before, we start with a production technology and the assumption that institutional quality depends on GDP per capita:

$$\begin{aligned} Y &= QK^{\beta}(AL)^{1-\beta} \\ Q &= \left(\frac{Y}{L}\right)^{\theta} \end{aligned}$$

where we assume that technical progress is labor-augmenting. The easiest way to analyze this model is to define efficiency units $X \equiv A^{\frac{1-\beta}{1-\beta-\theta}}$. If we then use $y \equiv Y/XL$ and $k \equiv K/XL$ to denote quantities in efficiency units, we can derive a reduced-form relationship between y and k:

$$y = k^{\frac{\beta}{1-\theta}}$$

We use g_A to denote the exogenous rate of technical progress. By solving for the balanced growth path, it can be shown that the long-run growth rate is equal to the growth rate of X, denoted $g_X \equiv ((1-\beta)/(1-\beta-\theta)) \cdot g_A$. Hence, given that $0 < \theta < 1-\beta$, long-run growth exceeds the rate of exogenous technical progress. Since there is continual improvement in institutions, the effect of technical progress on long-run growth is magnified. The extent of the magnification is increasing in both θ and β. We assume throughout that ρ is sufficiently high, and g_X sufficiently low, that lifetime utility is bounded. After solving the household's optimization problem and rewriting the system in terms of efficiency units, simulation of the model is straightforward.

The dependence of the long-run growth rate on the externality parameter (θ) raises a question for our quantitative exercise. As before, we assume that the donor is uncertain about the true value of θ, and wants to consider various scenarios. But

[17] See the longer discussion in Kraay and Raddatz (2007). A wider range of poverty trap models is discussed in Ghatak (2015).

now, to study alternative choices for θ, we have to ask whether the donor knows either the underlying rate of technical progress, or the long-run growth rate. If we assume the rate of technical progress is known, then varying θ leads to alternative long-run growth rates, since technical progress is magnified by institutional improvement to varying degrees. Alternatively, we could assume that the donor regards the long-run growth rate as known, but does not know the rate of technical progress. We adopt the former choice here, but our result that virtuous circles can modestly strengthen the case for aid also emerges under the alternative choice, discussed in an appendix available on request.

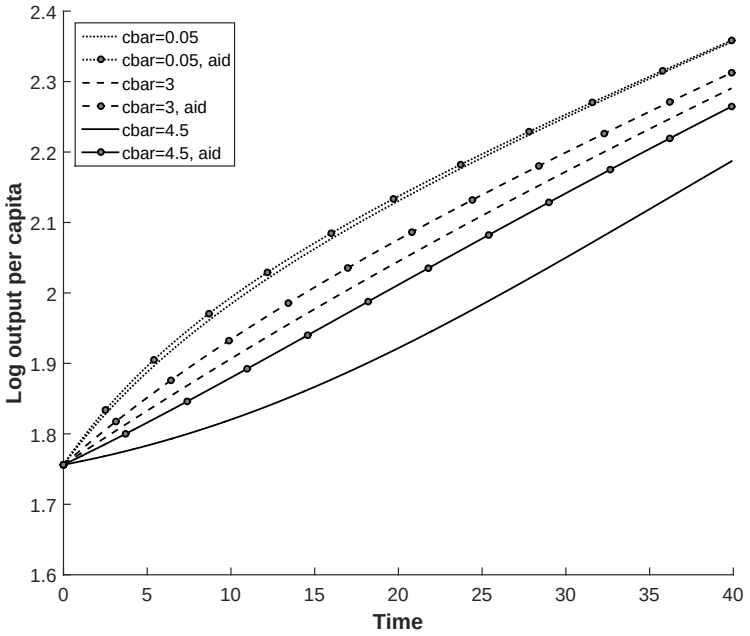
The introduction of long-run growth also requires us to specify how aid evolves over time. We posit the existence of a donor country, not modeled, that gives a constant proportion of its GDP as aid. This donor has essentially the same economic structure as the recipient, but with a higher level of productivity, and is on its balanced growth path throughout. Population growth (n) and long-run growth (g_X) are assumed to be the same in the donor and recipient. As in Carter, Postel-Vinay and Temple (2015), we set $n = 0.015$, based on the recent population growth rate of a set of recipient economies. We again use an initial value of aid equivalent to 20% of recipient GDP at time zero, but now total aid is growing at the same rate ($g_X + n$) as donor GDP. Although aid is growing, the assumptions imply that aid per capita will be constant in efficiency units.

We now examine the growth and welfare effects of aid as θ varies, while allowing the subsistence level of consumption $\bar{c}$ to vary across experiments. Recall that, when initial living standards are close to subsistence, the economy can experience a medium-run poverty trap. The initial level of capital is fixed across experiments at 11.60. With the rate of depreciation set at $\delta = 0.06$ and initial output per capita equal to 5.79, the amount of output available for consumption and net investment is around five units in the absence of aid. Since initial output is treated as known, we vary the relevance of the subsistence constraint by considering feasible values of $\bar{c}$ from zero to 4.50 units. We assume that the rate of exogenous technical progress is $g_A = 0.01$. The range for θ we consider, from zero to 0.40, implies that the long-run growth rate varies between 0.01 and 0.025, depending on the value of θ; this accommodates most conventional estimates of the long-run growth rate.[18]

We will study outcomes with and without aid, allowing the relevance of the subsistence constraint to vary. Note that, in Figures 5-10, lines with circle markers

[18]For example, Mankiw, Romer and Weil (1992) used an estimate of 2% a year for the long-run growth rate, and Jones (1995, p. 498) estimated US growth in GDP per capita over 1929-1987 as 1.75%. Note that higher values of θ, as well as raising the long-run growth rate, would bring the reduced-form production technology closer to linearity, which seems unrealistic.

Figure 5: Log output per capita ($\theta = 0$)



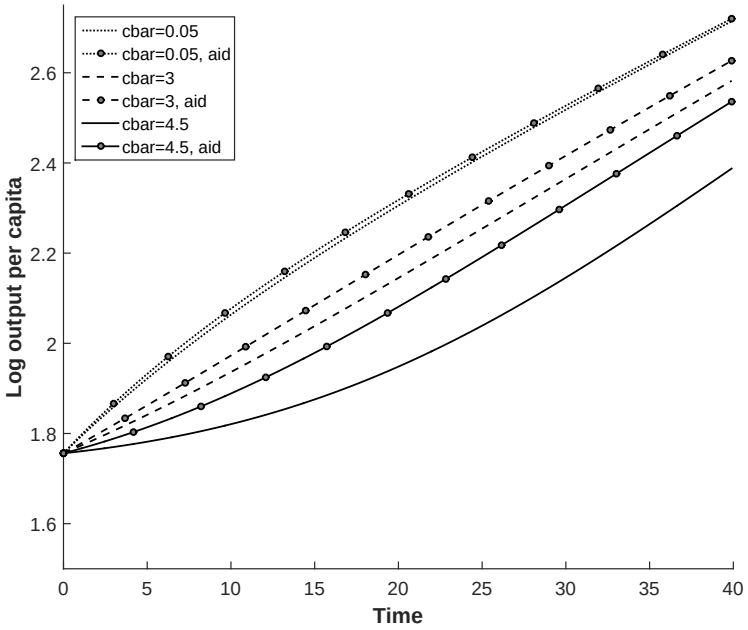
This figure shows the effect of aid on the path of log output per capita, for $\theta = 0$, as the level of $\bar{c}$ varies. In each case the output path is shown without aid (the lower of the paired lines) and with aid (the upper line of the pair, with circle markers).

will indicate a path with aid, and lines without markers, a path without. When examining the path of output, we plot the logarithm of output per capita so that differences in levels are readily discernible, and growth rates can be inferred from the slopes of the lines.

In Figure 5, for $\theta = 0$, although the recipients will ultimately converge to the same steady-state growth path, the nature of the transition depends on the initial proximity to subsistence. In particular, the initial rate of growth is much slower when initially close to subsistence, and the impact of aid on the output path is much greater. When an externality is introduced in Figure 6 ($\theta = 0.30$), while holding β constant, the steady-state growth path is steeper than before, but similar results apply: when the economy is initially close to subsistence, initial growth is lower, and aid makes a bigger difference to the path of output.

Figures 7 and 8 study how the output path varies with assumptions about the externality θ. The strength of the amplification effect determines the level and slope of the steady-state growth path, which now varies across cases. In Figure 7, where the subsistence constraint is negligible, the effect of aid on output is too small to be visible, since households barely alter their investment decisions. In Figure 8, the

Figure 6: Log output per capita ($\theta = 0.30$)



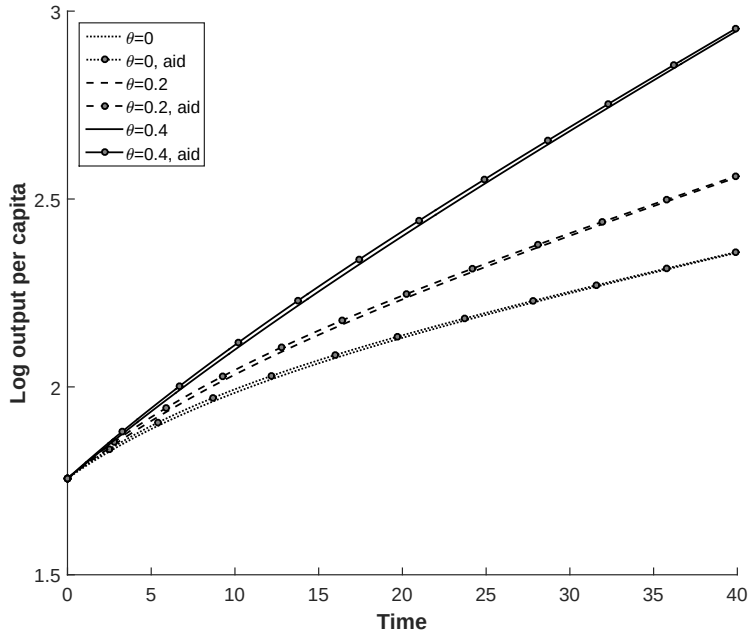
This figure shows the effect of aid on the path of log output per capita, for $\theta = 0.30$, as the level of $\bar{c}$ varies. In each case the output path is shown without aid (the lower of the paired lines) and with aid (the upper line of the pair, with circle markers).

economy begins close to subsistence, aid has a stronger effect on the output path, and this effect is larger for higher values of θ.

To understand the behavior of the model in more detail, Figures 9 and 10 plot the growth rate of the capital-labor ratio for various cases. These figures show that, when an economy begins close to subsistence, the growth rate of the capital-labor ratio is low and may even be negative, because the economy is temporarily trapped in low income and low investment. Foreign aid promotes faster growth of the capital stock. When θ is large, the effect of aid on the growth of the capital stock can be substantial. For example, consider the case where $\theta = 0.30$. We look at the maximum ratio of the capital stock with aid to that without aid, where the ratio is computed at each instant. When the subsistence constraint is almost absent ($\bar{c} = 0.05$), the ratio never exceeds 1.03, so the effect of aid on capital accumulation is modest — the capital stock is never more than 3% higher, at any given instant, than it would have been without aid. But with a more important subsistence constraint, the maximum ratio rises to 1.12 ($\bar{c} = 3.00$) or 1.40 ($\bar{c} = 4.50$). Hence, aid allows substantially faster accumulation of capital.

As θ increases, aid allows a faster exit from a vicious circle of low income and

Figure 7: Log output per capita ($\bar{c} = 0.05$)



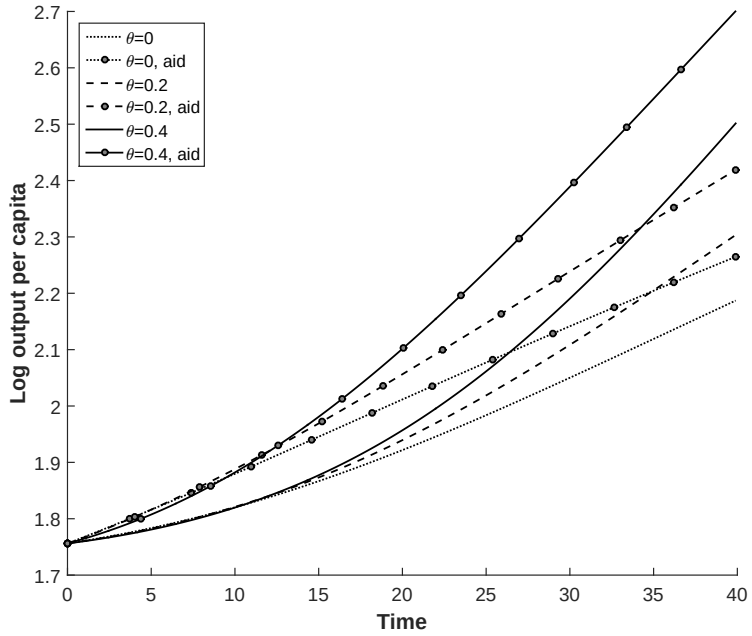
This figure shows the effect of aid on the path of log output per capita, for $\bar{c} = 0.05$, but varying the strength of the externality indexed by θ. In each case the output path is shown with and without aid, but aid barely influences the output paths in this case.

low investment. We can use this to reconsider the welfare-based case for aid, again measured using Hicksian equivalent variation.[19] We first look at the case with no amplification, but a major subsistence constraint ($\bar{c} = 4.50$) and $\beta = 1/3$. In this setting, aid leads to a welfare gain equivalent to a 25% consumption increase at each instant. As before, this is clearly a significant gain, but equally clearly, an order of magnitude less (at least) than international differences in consumption per capita. Now consider a case with amplification, $\theta = 0.30$, and hence a faster exit from the medium-run poverty trap. The welfare gain is then equivalent to a 29% consumption increase at each instant, which is larger than before, but not dramatically.

As before, amplification has offsetting implications for the welfare derived from aid. With higher θ, the output gains at short horizons from aid-induced investment are larger, but at the same time, the recipient's prospects are relatively good even in the absence of aid. Figure 11 shows how the welfare effects of aid are related to amplification, as the relevance of the subsistence constraint varies. It is worth noting that, since the utility functions differ across the cases — different subsistence levels are assumed — we should be wary of comparing welfare effects across different

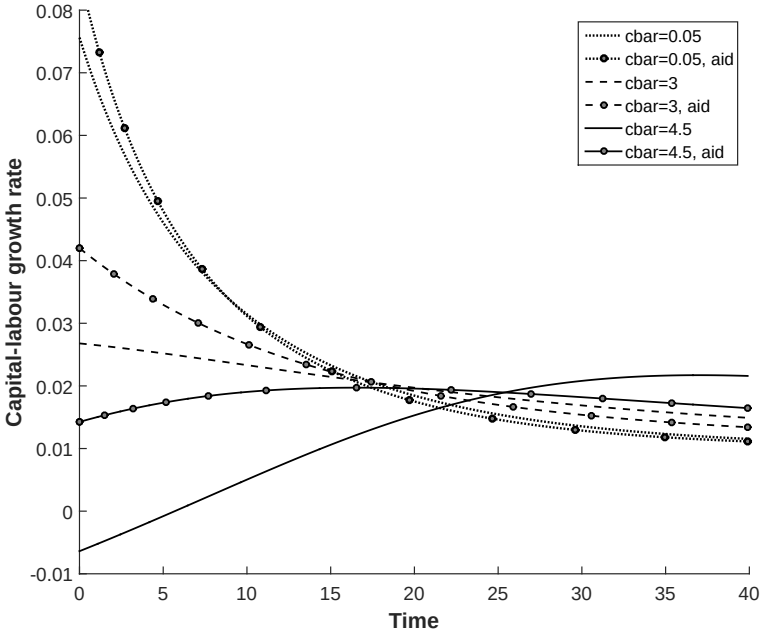
[19]There is no closed-form expression for this variation in the case of Stone-Geary preferences, so we obtain it numerically.

Figure 8: Log output per capita ($\bar{c} = 4.50$)



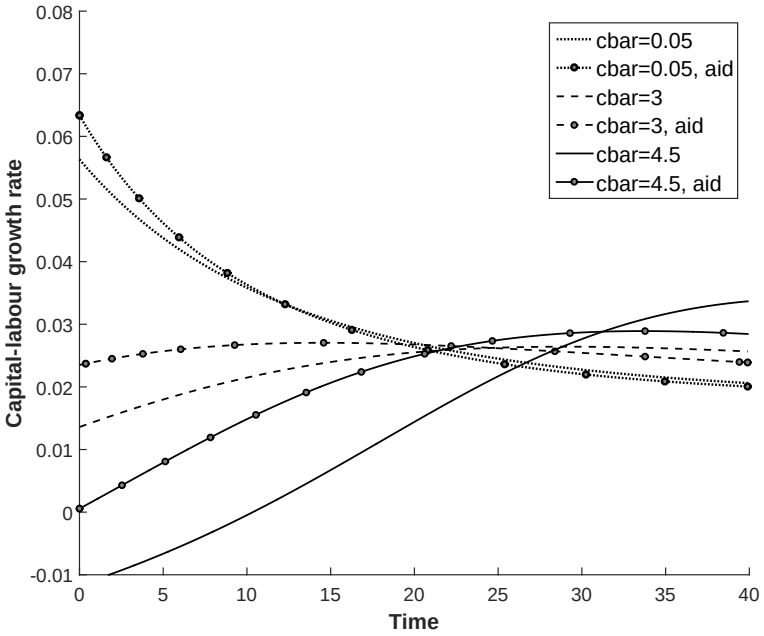
This figure shows the effect of aid on the path of log output per capita, for $\bar{c} = 4.50$, but varying the strength of the externality indexed by θ. In each case the output path is shown without aid (the lower of the paired lines) and with aid (the upper line of the pair, with circle markers).

Figure 9: Capital-labor growth ($\theta = 0$)



This figure shows the growth rate of the capital-labor ratio, with and without aid, for $\theta = 0$ and varying the relevance of the subsistence constraint $\bar{c}$.

Figure 10: Capital-labor growth ($\theta = 0.30$)



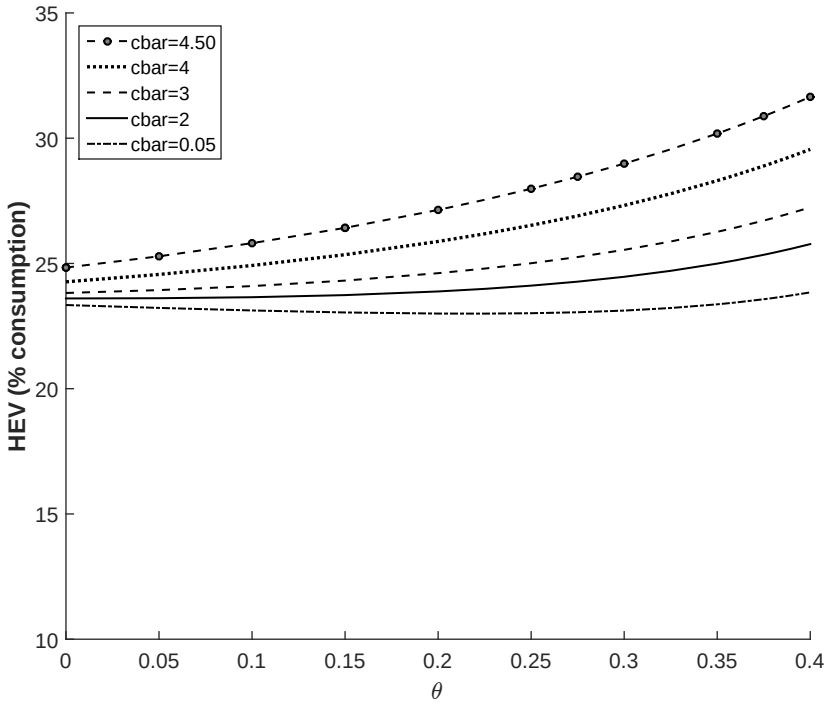
This figure shows the growth rate of the capital-labor ratio, with and without aid, for $\theta = 0.30$ and varying the relevance of the subsistence constraint $\bar{c}$.

experiments. We are more interested in the slopes of these lines. The figure shows that, when the recipient is initially close to subsistence or the externality is large, amplification effects can strengthen the case for aid (the lines are upward sloping). However, a look at the scale of the y-axis indicates that the slopes of the lines in the figure are relatively shallow. Amplification only modestly influences the welfare effects of aid, even when it allows an escape from a medium-run poverty trap.

In summary, the previous section showed that amplification effects may not strengthen the case for aid; in this section, they can do, by allowing a faster exit from a vicious circle. This is because, when an economy is caught in a vicious circle, its medium-run prospects are poor in the absence of aid. This tips the balance of effects so that the welfare benefits from aid are sometimes higher under amplification; but the difference made by amplification effects is relatively modest even in this case. Overall, our results suggest that the poverty trap debate may be less fundamental than is usually assumed, at least if the poverty trap is eliminated in the long run, as here.

The relevance of poverty trap models has often been discussed. Bourguignon, Levin and Rosenblatt (2004) find that, over 1980-2002, about two dozen countries recorded growth rates that were negative or close to zero. Considering longer spans,

Figure 11: The welfare effect of aid



This figure shows how the welfare benefits from aid, expressed as Hicksian equivalent variation, vary with the extent of the externality and the proximity to subsistence.

however, Easterly (2006) argues that there is little historical evidence for poverty traps, or for take-offs induced by aid. More recently, Kraay and McKenzie (2014) argue that many of the mechanisms that give rise to poverty traps are not well supported in the data. In a study that is partly focused on the Ramsey model with Stone-Geary preferences, Kraay and Raddatz (2007) find that PPP-adjusted consumption levels vary quite widely across countries in sub-Saharan Africa. This calls into question the idea of a subsistence constraint which applies to many countries simultaneously. Nevertheless, they also find that for samples of low-income countries and sub-Saharan African countries, saving rates are increasing in capital per person, which is more consistent with the subsistence consumption approach. Sachs (2005, pp. 56-57) makes a similar point.

We began the paper with a reference to the Marshall Plan, and our results could seem to contradict the usual view of its importance. We have shown that large-scale transfers — equal to 20% of initial recipient GDP — have significant welfare benefits, but not on a scale to make them central to achieving prosperity.[20] There are several

[20]The Marshall Plan did involve large transfers, since the US donated one per cent of its GDP on average over the years it operated (Crafts, 2013).

possible interpretations of this result. One is that the significance of the Marshall Plan may have been overstated by some observers. Another is that definitions of success vary: they might relate to much wider goals, such as securing the political stability of postwar Europe.[21] Well-designed, large-scale aid programmes can have benefits which extend beyond their effects on investment and productivity.

Related to this argument, in the models considered in this paper, the potential effects of aid are sharply circumscribed. Aid makes additional resources available for consumption and investment, but has no direct effect on productivity. Even the effect on investment is ultimately limited, because the height of the steady-state growth path is invariant to aid. It is likely that stronger effects of aid would emerge in models where aid directly influenced the path of productivity. Virtuous circles could still play a role, not least in amplifying the effects of a given productivity increase.

Some commentators regard aid as a catalyst. If aid sparks a moribund economy into life, the comparison between the growth path and the no-aid benchmark might be more favourable to aid.[22] Hence, a more ambitious theoretical project would consider alternative models in which aid is a catalyst for growth. There are many models of multiple equilibria and poverty traps, and some of these suggest a case for a 'Big Push' based on high aid flows; but there are fewer models in which relatively modest aid flows can prompt a growth take-off. Moreover, the idea of aid-as-catalyst has barely influenced work which seeks to quantify the effects of aid. Among the papers in which aid allows exit from a poverty trap, Mourmouras and Rangazas (2007) is unusual in studying welfare consequences in quantitative terms. In the empirical literature, the most relevant paper is Dovern and Nunnenkamp (2007), building on the work of Hausmann, Pritchett and Rodrik (2005) on growth accelerations. Otherwise, a remark of Pronk (2001, pp. 619-620) continues to have some force: 'if aid were conceived not as a direct cause of development, nor as its origin, its source or its prime mover, but only as a catalyst, many studies of the impact of aid could have been left undone or replaced by less abstract analyses'.

6 Conclusions

This paper has studied whether amplification effects and virtuous circles strengthen the case for aid. The standard intuition is that they must. But a formal analysis calls this belief into question: in the neoclassical growth model, an amplification effect

[21] Gimbel (1976) discusses the wide range of objectives that have been attributed to the Marshall Plan.

[22] For an informal discussion of this role for aid, see Rogerson (2011).

implies good long-term consumption prospects even in the absence of aid. Although donors can take advantage of virtuous circles, so can other sources of investment, such as domestic saving. We therefore compare paths with and without aid for different scenarios. The welfare gains associated with aid are found to be *lower* when virtuous circles are present, because virtuous circles will allow the economy to grow quickly even in the absence of aid.

There are two main qualifications to this result. The first, and least important, considers the decision problem of a donor with imperfect knowledge. A donor who knew the reduced-form output-capital elasticity (for example, from empirical estimates) but not the importance of the externality, would infer larger welfare gains from aid when assigning the externality a more important role. This is because, for a given reduced-form output-capital elasticity, an economy with a relatively important role for the externality has worse consumption prospects. Hence, it will benefit more from aid transfers.

The second qualification is more important, and emphasizes the role of a take-off into self-sustained growth. We considered a model with a subsistence level of consumption, generating a vicious circle of low income and low investment. Aid then allows this economy to achieve escape velocity earlier in the development process, especially when the effects of capital accumulation are amplified. The welfare effects of aid are significant, and sometimes higher under amplification. This implies that the case for aid is strengthened, in line with intuition. But in the models we consider, the effect of aid on the capital stock is never large enough to transform a country's prospects.

For aid to have stronger effects, alternative models would be needed. One approach would be to develop models in which aid has a direct effect on productivity, perhaps in conjunction with mechanisms that amplify a given productivity increase. Another promising route might be to treat aid as a catalyst, setting a virtuous circle in motion, for economies otherwise likely to remain at low income levels. It is often argued informally that aid can unblock a growth process, initiating a transition away from stagnation or instability and towards sustained development. We have captured this idea in a simple way using Stone-Geary preferences, but there are many other possibilities, and only a few have been studied in quantitative terms in the literature. Further, the implications for empirical work of aid-as-catalyst could be important, and remain largely uninvestigated.

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